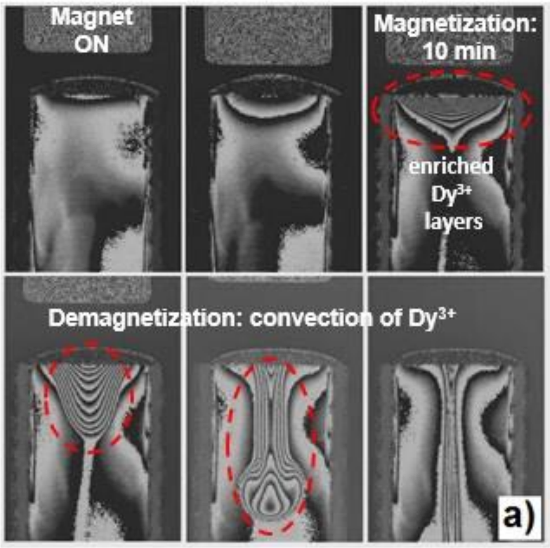
Magnetomigration of rare-earth ions in strong magnetic fields

Speaker Name: Isadora R. Rodrigues
Speaker Affiliation: Department of Material Engineering, KU Leuven, Kasteelpark Arenberg 44, P.O. Box 2450, B-3001 Heverlee, Belgium
Co-authors: Liubov Lukina, Sam Dehaeck, Pierre Colinet, Koen Binnemans, and Jan Fransaer.

Abstract

The use of magnetic fields to manipulate macroscale particles is a well-known method applied to the separation of magnetic materials.[1] The energy of paramagnetic species exposed to an external magnetic field decreases as the magnetic force pulls them towards stronger magnetic fields. The opposite occurs for diamagnetic species, which tends to move to regions with weaker fields. Encouraging results are found in the recent literature for the magnetic separation of paramagnetic ions.[3-5] However, the effect of an external magnetic fields on small molecules and ions, is rather controversial. The magnetically induced movement of single ions in solution, is likely to be overpowered by the high kinetic energy of the system due to Brownian collisions.[6]

In the present work, Mach-Zehnder interferometry (MZI) was used to study the magnetomigration of rare-earth (RE) ions. Two RE ions were selected for the experiments based on their distinct magnetic properties: the strong paramagnetic Dy^{3+} (magnetic susceptibilities $\chi > 0$) and the diamagnetic Y^{3+} (magnetic susceptibilities $\chi < 0$). No migration of ions was found for a thermodynamically closed system when a perfectly homogeneous solution was subjected to an external magnetic field. However, when a concentration gradient was introduced in the sample by solvent evaporation, consistent migration of paramagnetic Dy^{3+} ions was observed, from the bulk solution to regions with stronger magnetic fields (Figure 1a-b). By contrast, no movement was detected for diamagnetic Y^{3+} ions, notwithstanding the presence of a concentration gradient.



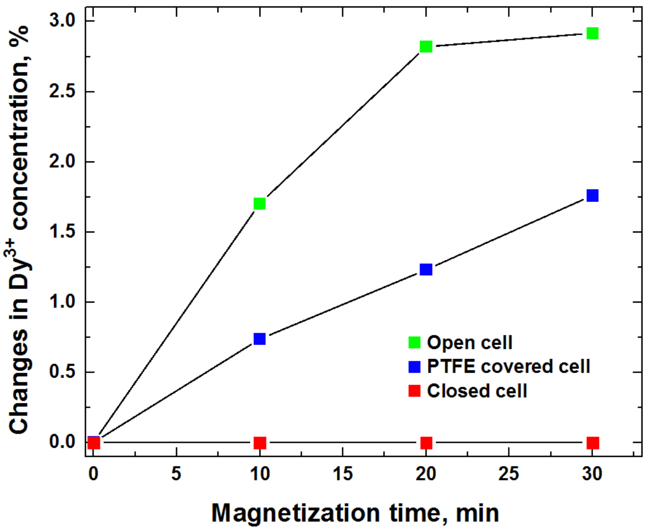


Figure 1: a) MZI contour plots obtained for 1.0 M Dy^{3+} solution in an open cell with higher evaporation rate; b) changes in the Dy^{3+} concentration due to magnetization: green – higher evaporation rate; blue – lower evaporation rate; red – no evaporation.

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Biography

Isadora Reis Rodrigues (born 20/11/1982, Brazil) obtained in 2010 a master degree in Chemistry, at the University of Montreal, Canada. The topic of her thesis was the synthesis and characterization of cathode materials for li-ion batteries. In 2016, she joined the Department of Material Engineering at KU Leuven University (Belgium), to start her PhD on the topic of magnetic separation of rare-earth ions. She is author (or co-author) of 6 publications in international journals.

Email:
isadora.reisrodrigues@kuleuven.be
isadora.rrs@gmail.com
Contact number: +32 16 37 36 77